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CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L. MARK, DIRECTOR. No. 178.

REACTIONS OF *TUBULARIA CROCEA* (AG.)

A. S. PEARSE

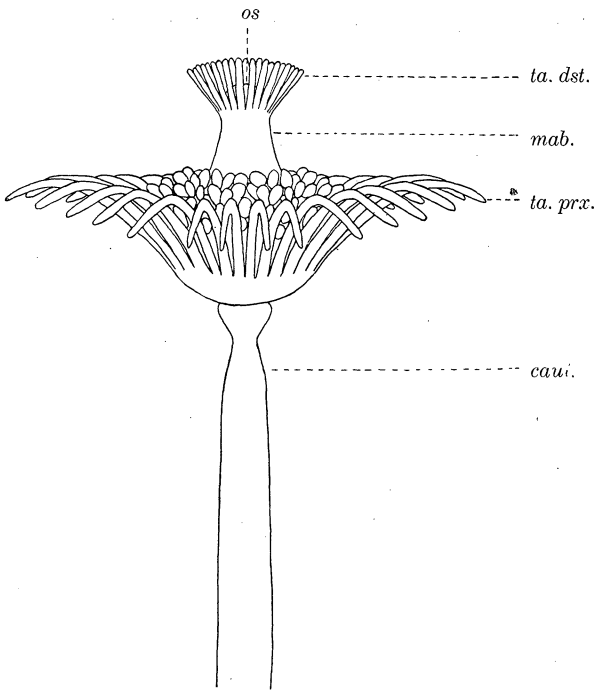
WHILE the reactions of sea anemones and of jelly fishes have been carefully studied, comparatively little is known of those of hydroids. In fact, the only recent paper which deals primarily with this subject is one by Torrey (:04) on *Corymorpha palma*. He found that this hydroid gives well marked reactions to gravity and mechanical stimulation, but does not respond to chemical stimulation.

The work upon which the present paper is based was undertaken at the suggestion of Professor G. H. Parker, and the experiments were carried on at the Laboratory of the United States Bureau of Fisheries at Wood's Hole, Mass. My thanks are due to the director, Dr. F. B. Sumner, for the courtesies shown me at the Wood's Hole Laboratory and to the Museum of Comparative Zoölogy for pecuniary assistance granted from the Humboldt Fund.

The material, consisting of colonies of Tubularia, was scraped from the piles of the wharf at the Fisheries Station and examined in sea water within three hours of the time of collection. The colonies are rather delicate and are easily rendered inactive or killed by unfavorable conditions. Small portions of colonies, containing from twenty-five to fifty polyps, were used in these experiments.

The accompanying figure represents an expanded hydranth of *Tubularia crocea* and a short portion of the stalk upon which it is borne. In a resting hydranth the proximal tentacles (*ta. prx.*) are bent slightly back toward the stalk (*caul.*) and remain motionless except for an occasional sudden movement toward the mouth (*os*), after which they slowly return to their former position. The distal tentacles (*ta. dst.*) are more active and are usually in motion,

bending back and forth singly or collectively. The manubrium (*mab.*) is ordinarily motionless, but may shorten or lengthen and, when stimulated, is capable of bending even to such an extent that



the mouth is brought below the bases of the proximal tentacles. The whole hydranth may be moved by the bending of the stalk, but this action is not of frequent occurrence and it is apparently not called forth in response to direct stimulation.

MECHANICAL STIMULATION

When a proximal tentacle is touched with a needle or pinched, it bends toward the manubrium. The strength of the stimulus influences the response. If the stimulus is weak, there may be no reaction, but if it is strong, the whole circle of tentacles may close up together and press against the manubrium. If the manubrium or the distal tentacles are stimulated in a similar manner, the for-

mer bends toward the point of stimulation and a few or all of the distal tentacles wave about for a short time. If in this process they touch some object, they then close up around the mouth. When the stimulation is very strong, the manubrium shortens and both sets of tentacles close up around it.

The hydranths will submit to considerable mechanical stimulation without reaction. For example, a stream of water forced from a pipette upon an expanded individual will cause no movement unless the current is rather strong.

If a proximal tentacle is pulled vigorously, the manubrium will turn so that the mouth is brought toward the stimulated point and the distal tentacles will open out. However, as each set of tentacles may be made to react independently and without apparent influence on the other set, it seems probable that in this case the manubrium is strained and thus stimulated directly.

The reactions described above are doubtless helpful to the animal in securing food, though they are not perfectly adapted to this purpose. They are not very accurately adjusted to the gathering of food, for the proximal tentacles will always move toward the mouth even when the point of stimulation is on the outer face, in which case they move directly away from what may be food.

Chemical Stimulation

When a proximal tentacle is touched with a piece of meat at any point, it bends toward the mouth. The meat, if it is on the inner face of the tentacle, is pressed against the mouth for a time and then the tentacle slowly returns to its former place. All the proximal tentacles often close up in the presence of meat, but those in contact with it react first and remain closed after the others have opened out, which they usually do quickly. If meat is placed very gently on the proximal tentacles, no reaction takes place and it falls off or remains resting upon them. Sometimes when meat is placed upon them, the bending reaction takes place, but this is so feeble that the meat does not move far enough to reach the distal tentacles and in such cases there is no movement of the manubrium or distal tentacles. When meat comes in contact with the distal tentacles,

however, they bend outward and the manubrium turns them toward the stimulated side. If they then touch the meat, they close up around the mouth.

These reactions make it appear as though the procuring of food depended wholly upon mechanical stimulation, as Torrey has claimed in the case of Corymorpha; but the following experiments have led to a somewhat different conclusion. When a grain of sand is placed on one side of a hydranth,—being allowed to rest upon the proximal tentacles and to touch the distal ones,—and a piece of meat is placed in a corresponding position on the opposite side, the manubrium almost invariably turns toward the meat and the distal tentacles open out. In another experiment meat juice was extracted and filtered. This filtrate has a milky appearance and can easily be seen in water. When it is allowed to flow gently from the mouth of a pipette on the proximal tentacles, no reaction takes place, but as soon as it touches the distal tentacles they expand and the manubrium bends toward the stimulated side. To prove that these reactions are not due to mechanical stimulation produced by particles of solid matter or by currents, the same experiment was tried using powdered carmine in sea water instead of meat juice.

In 15% of the trials (685) with carmine water the mouth was turned toward the stimulated side and the distal tentacles opened out, but when the meat filtrate was used upon the same individuals the turning and opening-out reactions took place in 82% of the trials (717).

A third experiment points in the same direction. If the distal tentacles of an active hydranth are touched several times with a needle, they close tightly over the mouth. If, after a moment, they are touched again with the needle, they remain closed for some time; but if as a second stimulation they are touched in the same manner with a piece of meat instead of a needle, they at once open out and wave about.

From the above experiments it is reasonable to conclude that the distal tentacles, and perhaps the manubrium, are sensitive to a substance or substances contained in meat juice, while the proximal tentacles are not.

The effect of other chemical substances was tested without ob-

taining particularly significant results. When treated with dilute onion juice, quinine solution, or acetic acid, the hydranths closed up for a time, and if the solution was strong enough, they were killed. These substances, unlike meat, produce the same reactions as does strong mechanical stimulation.

Filter paper soaked in meat juice, onion juice, clove oil, or oil of bergamot and held near the hydranth caused no reaction of any part, the animal being apparently insensitive to the resulting very dilute solutions.

Thermal Stimulation

Colonies of Tubularia were placed in glass dishes and the effect of a rise or fall in temperature noted. When the temperature of the water was raised above 25° C. most of the animals were inactive, though two individuals turned the proboscis and opened out the distal tentacles when, at 27.5° C., they were touched with meat. No animal, after having been heated to 26° C. and then cooled again to normal[1] temperature, survived and reacted normally. When the water was cooled to about 10° C. most individuals became inactive to meat, though a few reacted to this form of stimulation even at 0° C. Probably the colonies survive any temperature down to near freezing, as individuals which had been for half an hour in water which was frozen (−2.2° C.) at the bottom of the dish and had a temperature of 1.5° C. at the top, gave the usual reactions thirteen hours later at a normal temperature. In no case did animals survive actual freezing in the ice. In extreme changes of temperature, the proximal tentacles cease to react before the distal ones, and this is what might be expected from the relative sensitiveness of the latter.

Local thermal stimulation was attempted with a bent capillary heated tube, or cooled by a current of water such as Mast (:03) used in his experiments on Hydra. The tube was held near the hydranth but not allowed to touch it. A cold tube (ice water) caused no perceptible effect on any part of the hydranth, but a hot

[1] The average temperature (readings at 8.00 A. M. and 5.00 P. M.) at Wood's Hole during the first ten days in August, 1905, was 19.8° C.

tube caused a restless indeterminate movement of the distal tentacles.

PHOTIC STIMULATION

No extensive experiments with light were attempted. Colonies were placed in the dark and then suddenly illuminated by a 16 c. p. electric light, or a shadow was cast over them after they had been illuminated for some time, but no observable reactions occurred in either case. It was also noted that the colonies grew just as abundantly on the sides of the piles most exposed to light as on those least exposed.

SUMMARY

1. The proximal tentacles of *Tubularia crocea* react to mechanical stimulation by bending toward the manubrium.

2. The distal tentacles react to mechanical and chemical stimulation by bending toward or away from the mouth, and this action may be accompanied by a bending of the manubrium toward the stimulated side.

3. Apparently no part of the hydranth is sensitive to very dilute solutions of meat juice, onion juice, and oil of cloves or bergamot (so called "odorous" substances).

4. The minimum temperature at which reactions occur is 0° C. and the maximum about 26° C.

5. Sudden change from strong light to shadow or from darkness to strong light has no apparent effect upon the animals.

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